

**CRS, the CERES Footprint-scale
Surface and Atmosphere Radiation Budget (SARB)
Clouds and the Earth's Radiant Energy System (CERES)
Science Team Meeting (Newport News, Apr. 28-30, 2009)**

T. P. Charlock (NASA LaRC)
Fred G. Rose (SSAI) Part II of this talk

David A. Rutan (SSAI) - Surface validation with CAVE
Zhonghai Jin (SSAI) - Coupled Ocean Atmosphere Radiative Transfer (COART)
Wenying Su (SSAI) - UV, PAR algorithms
Seiji Kato (LaRC) - “Super” SARB with Calipso/CloudSAT (C3M)
David Fillmore (Boulder) - MATCH aerosol assimilation
Thomas E. Caldwell, Lisa H. Coleman (SSAI) - Data Management

SARB/SOFA Working Group Wednesday Morning:

Net atmosphere analysis using ARM SGP cluster
Kratz on SARB/SOFA/ground match up
Rose on Calipso/CloudSAT (C3M) perspective
Rutan on MODIS Land Albedo for Edition3

Ungridded SARB vertical profile at ~2,000,000 CRS footprints/day

Langley Fu-Liou radiative transfer: Kato 2005 SW upgrade, Kratz-Rose LW window

NCEP O₃(z)
Mostly from SBUV/2

70 hPa (altitude ~18 km)

GSC NWP

GEOS4 T(z), q(z), surface wind
Jin ocean surface albedo = f(wind)

Modis Atmosphere Team

MINNIS modis

MODIS ~1km pixels provide
Cloud properties (almost always)
Aerosol AOT (sometimes)
Land skin temperature (if clear)

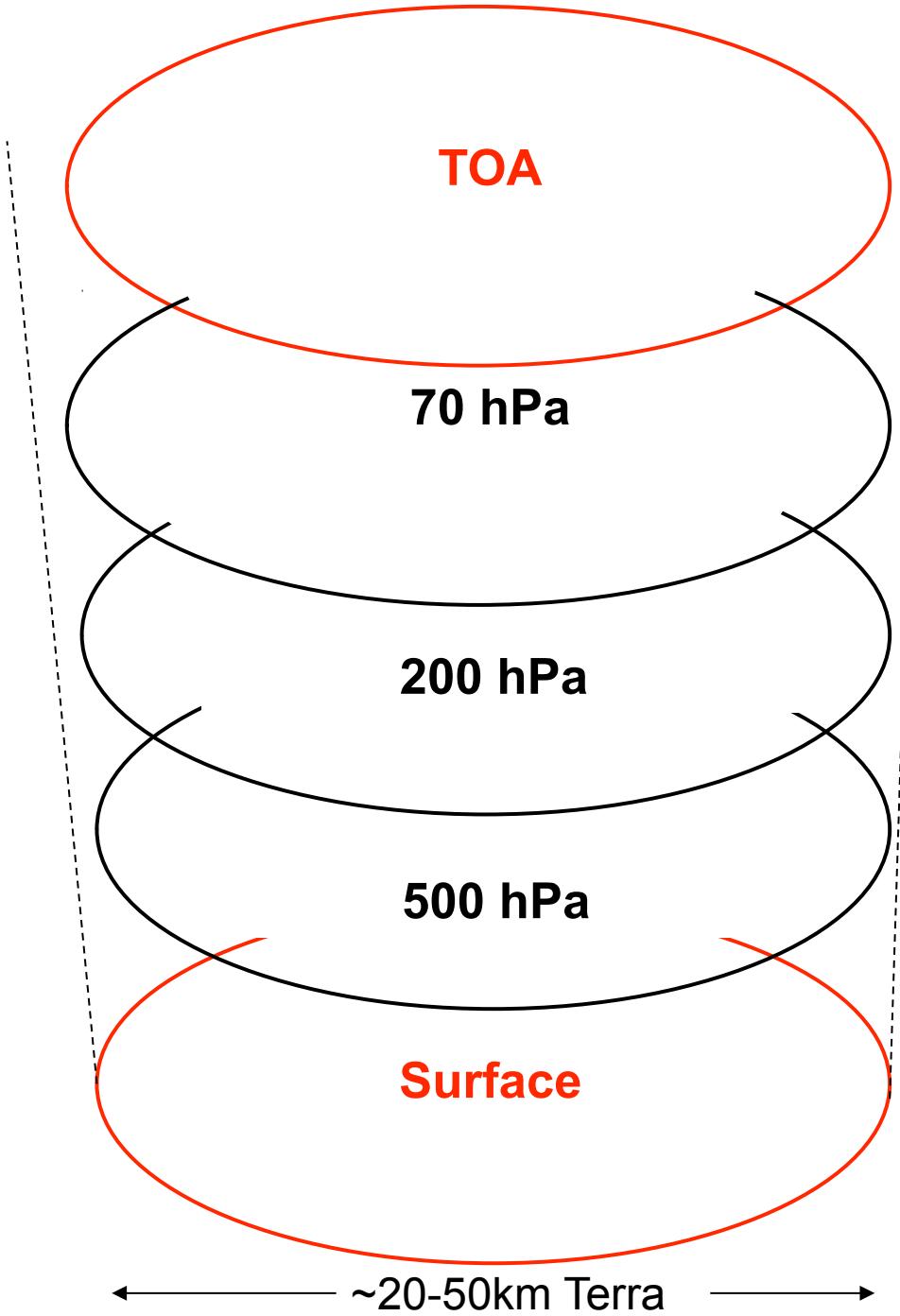
David Fillmore
MATCH aerosols
Always used for SSA & g
Used for AOT if no MODIS AOT

Surface

~20-50 km

Wielicki *Matthews*
Loeb *Priestley*

Large CERES footprint
for TOA flux



CERES CRS: Surface and Atmosphere Radiation Budget (SARB) Product

Tuned fluxes at all 5 levels
All-sky & Clear-sky, Up & Down,
SW and LW

Surface & TOA also have Untuned fluxes
Fluxes with aerosols
Pristine fluxes (no aerosols)

Aerosol forcing for
all-sky & clear-sky

Tuning does NOT yield a perfect
match to TOA observations.

Parameters adjusted when clear:
Skin temperature, aerosol AOT,
precipitable water (PW)

Parameters adjusted when cloudy:
LWP/IWP, cloud top temperature,
cloud fractional area within footprint

NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION

FIND IT @ NASA : + GO

CERES/ARM Validation Experiment (CAVE)

Home Surface Observations Satellite Data Atmospheric Profiles Global Surface Albedo Global UV Index Links

Welcome to the CAVE web site. Data collected in this effort are meant for use in validation studies of Clouds & The Earths Radiant Energy System (**CERES**) instruments operating on the and Earth Observing Systems(EOS) **Terra** & **Aqua** & Tropical Rainfall Measurement Mission (**TRMM**) satellites.

Extensive Surface Coverage
List of Surface Sites

Collocated CERES Observations

Continuous Surface Data Record

Atmospheric Profiles

Referencing CAVE data

Radiation Transfer 'on-line' models

- COART Coupled Ocean-Atmos RT Model
- Ocean Albedo Look-up Table
- Langley Fu & Liou On-Line Radiation Transfer
- CRS Advice
- Related Activities
- COVE Ocean Validation Platform
- CLAMS 2001 Aircraft Field Exp
- ULDB Balloon Observations

CAVE is an informal record containing radiation and meteorological data for a number of specific sites having

- (1) CERES top-of-atmosphere (TOA) broadband observations in *low volume, easy to use, subsets* collocated with,
- (2) surface broadband flux measurements from ARM, SURFRAD, CMDL, and BSRN networks.

Please read the [CAVE overview](#) for a complete introduction to the project.
 Questions, comments, or information about these data or these pages may be directed to:

+ Freedom of Information Act
 + Budgets, Strategic Plans and Accountability Reports
 + The President's Management Agenda
 + Privacy Policy and Important Notices
 + Inspector General Hotline
 + Equal Employment Opportunity Data Posted Pursuant to the No Fear Act
 + Information-Dissemination Priorities and Inventories
 + USA.gov
 + ExpectMore.gov
 + Multimedia Browser Plug-ins

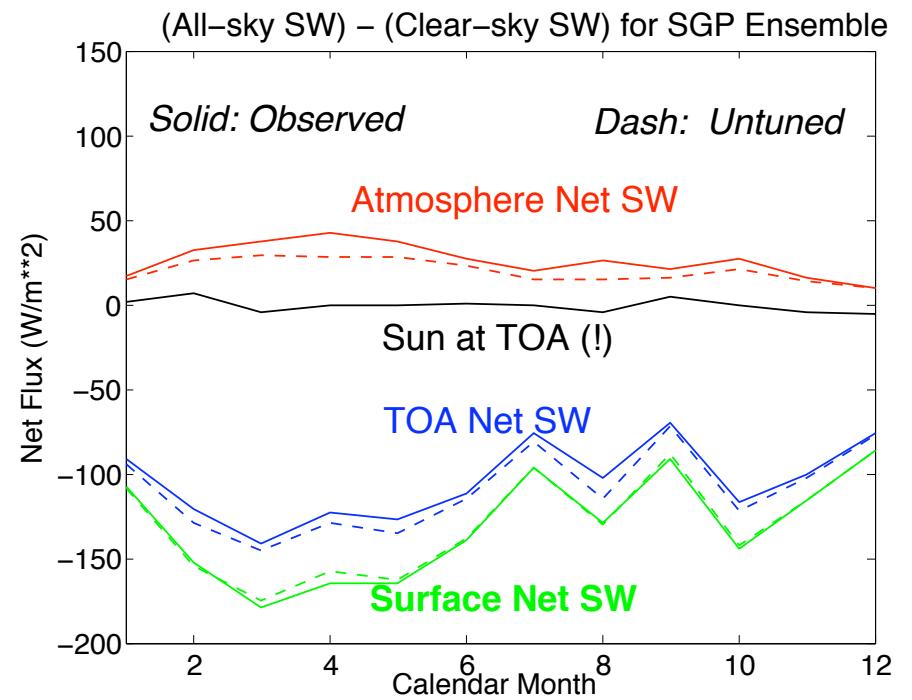
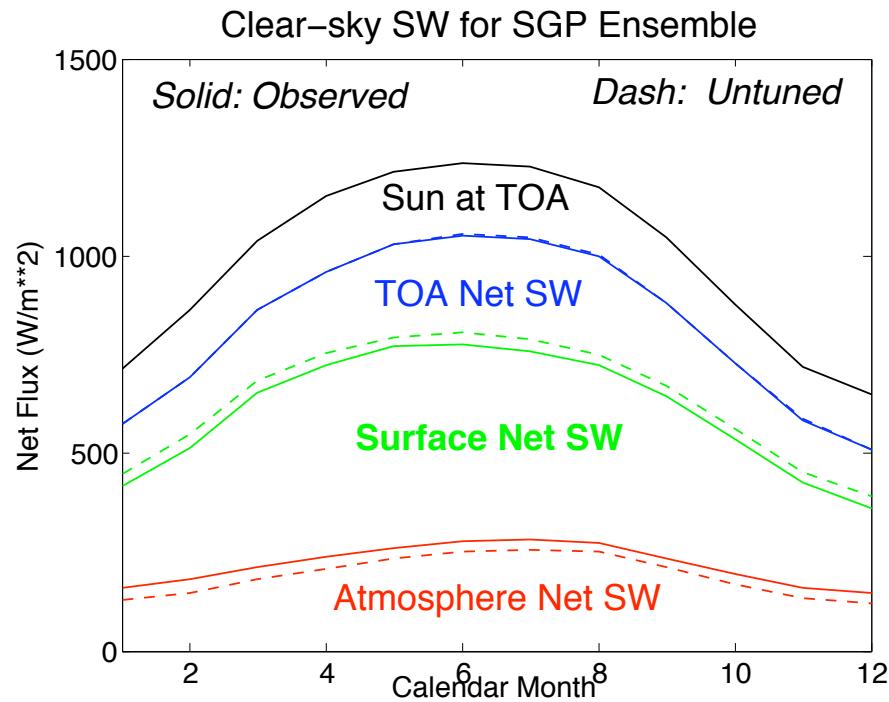
Curator: David Rutan
 NASA Responsible Official:
 Dr. Thomas Charlock
 Last updated: 04/28/2009 08:41:26

www-cave.larc.nasa.gov/cave/ or google “CERES CAVE”

Easy to use subsets of data, on line radiative transfer, ocean albedo tables...

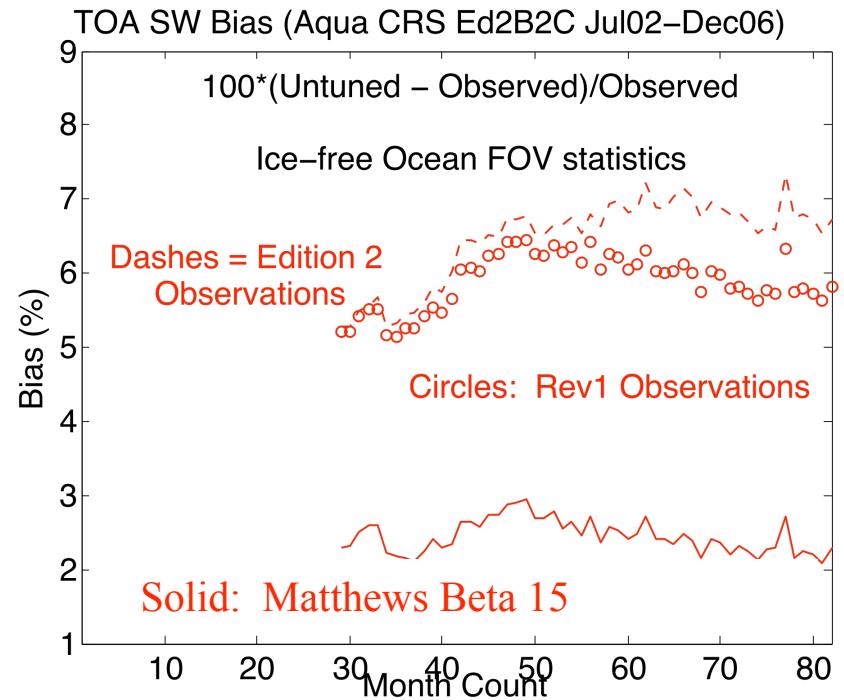
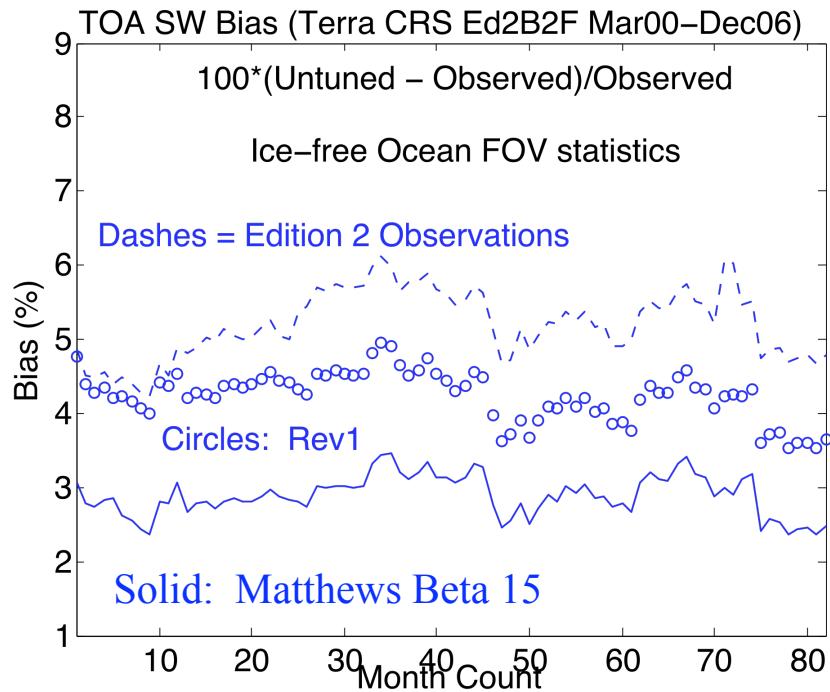
Routine validation at \sim 50 ground measurement sites.

Example of validation with cluster of 19 ARM SGP sites:



Bias of Calculated SW at TOA (all-sky, ice-free ocean)

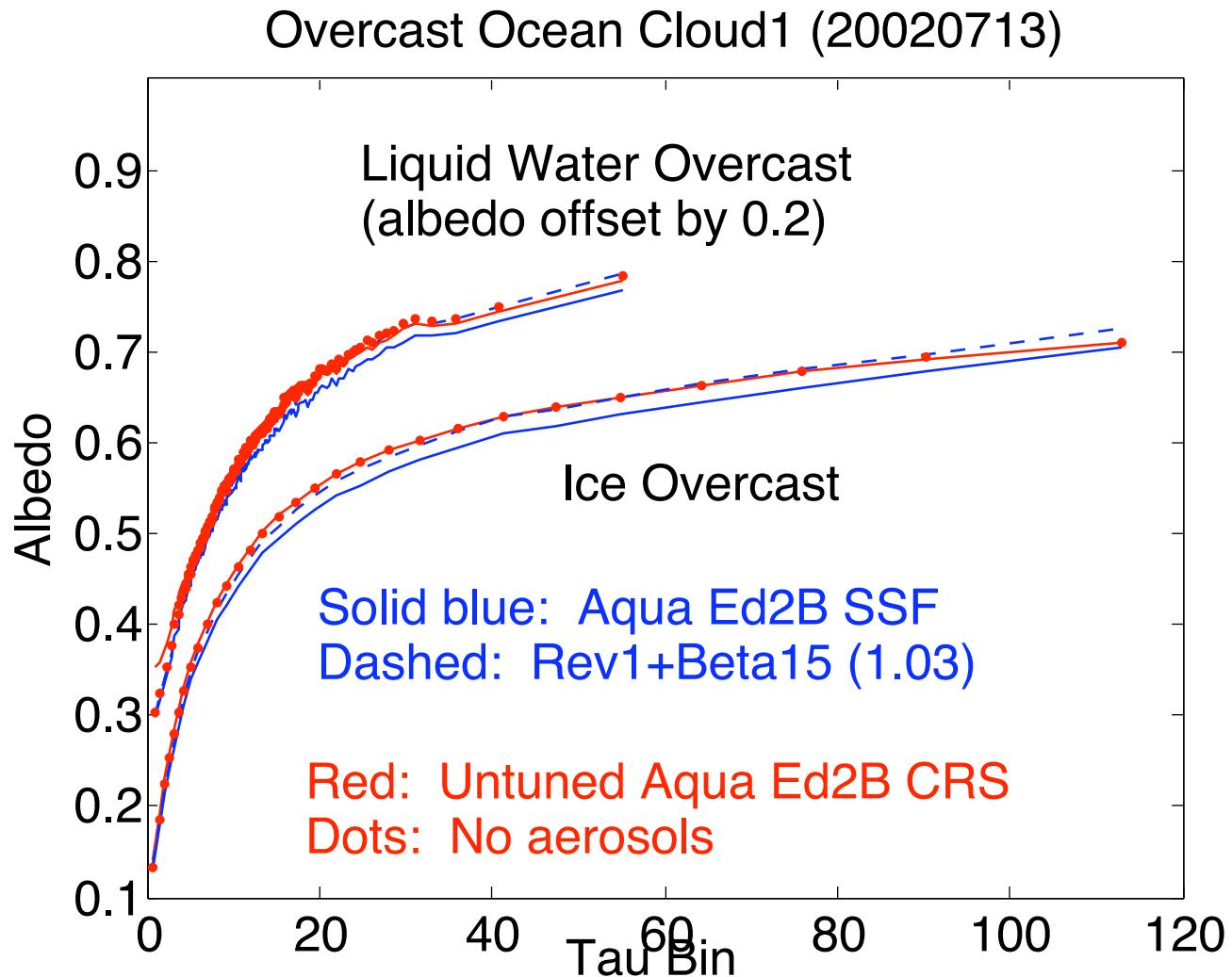
For each field, compute monthly average, deseasonalize, then form bias.



Untuned SW calculation uses no CERES broadband data over ice-free ocean.

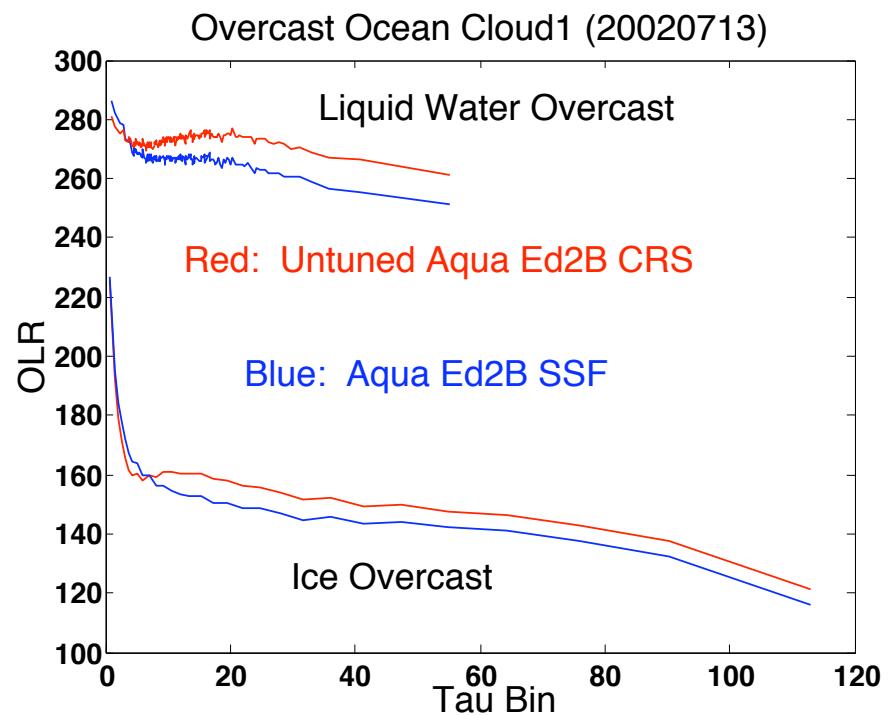
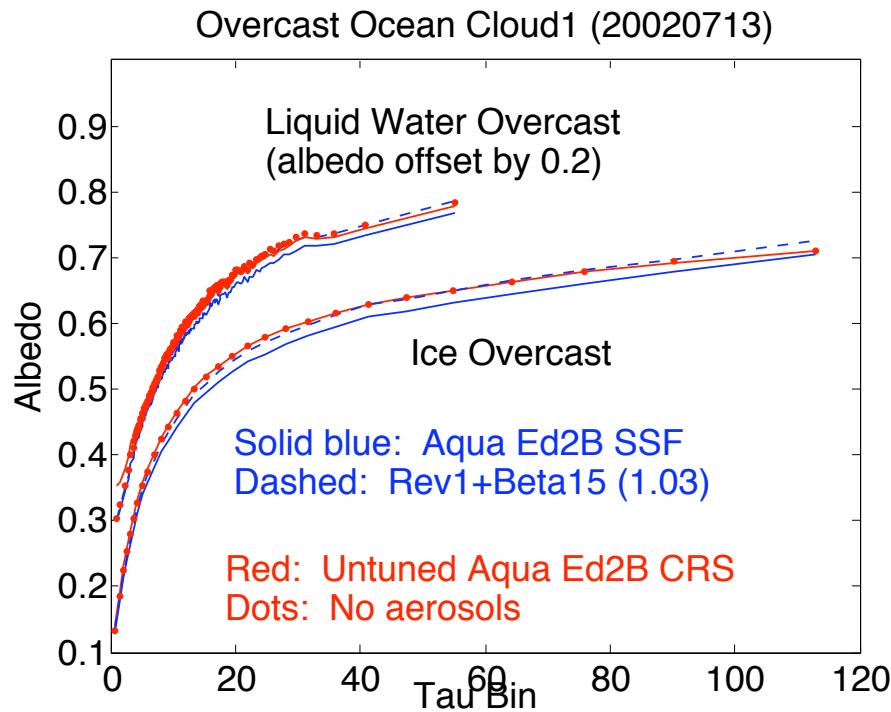
For both Terra and Aqua, these original SARB CRS Edition 2 calculations have less bias and less trend with Rev1 modifications to SSF Edition 2 observations, and even less when compared with Beta 15 modifications to observations.

One day of Aqua (no bugs in SARB code), overcast (pretty sure about cloud fraction, so focus on just cloud optical depth), and ocean (input for surface optics not dependent on CERES broadband measurement).



Large biases for computed OLR:

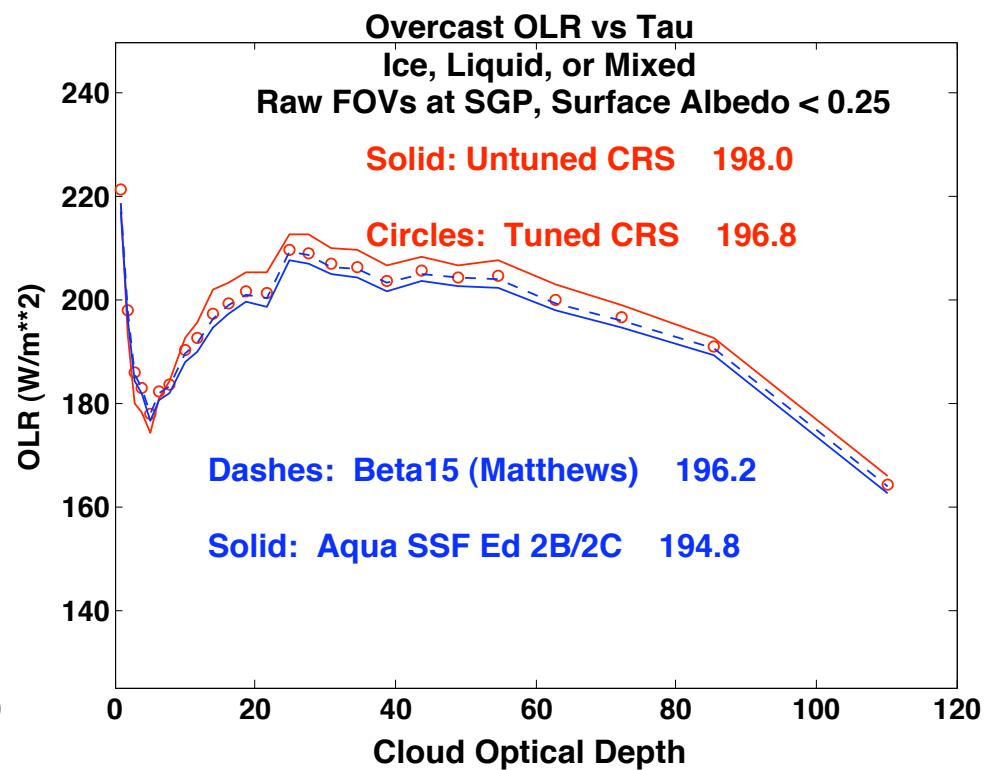
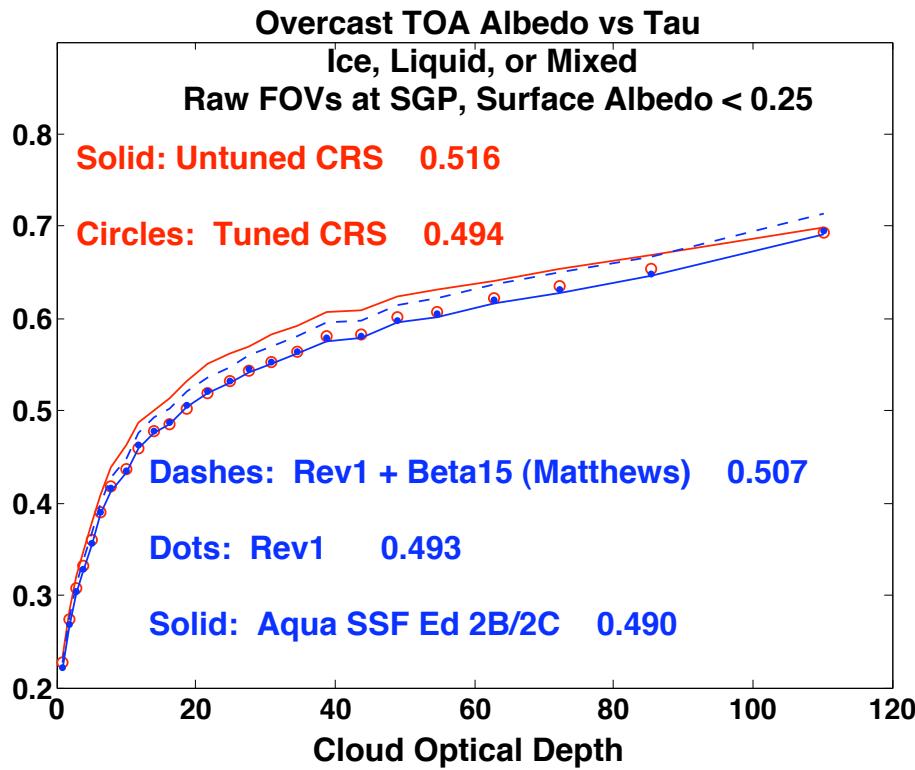
Are marine soundings unreliable?



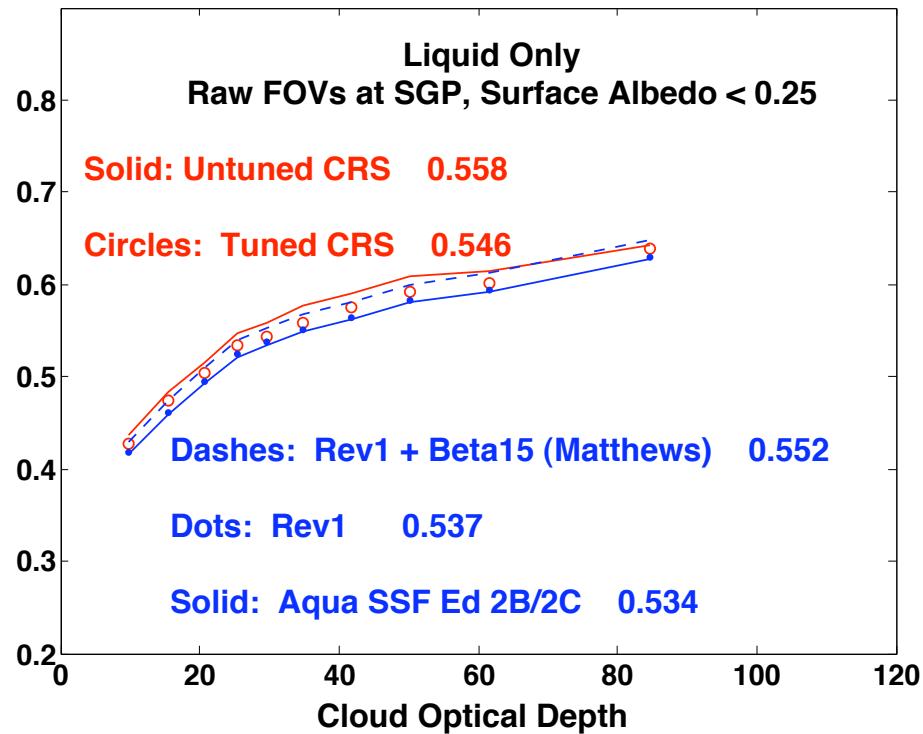
And cirrus tops are too fuzzy for accurate placement?

A look at ARM SGP cluster, where we have surface data and good sounding inputs.

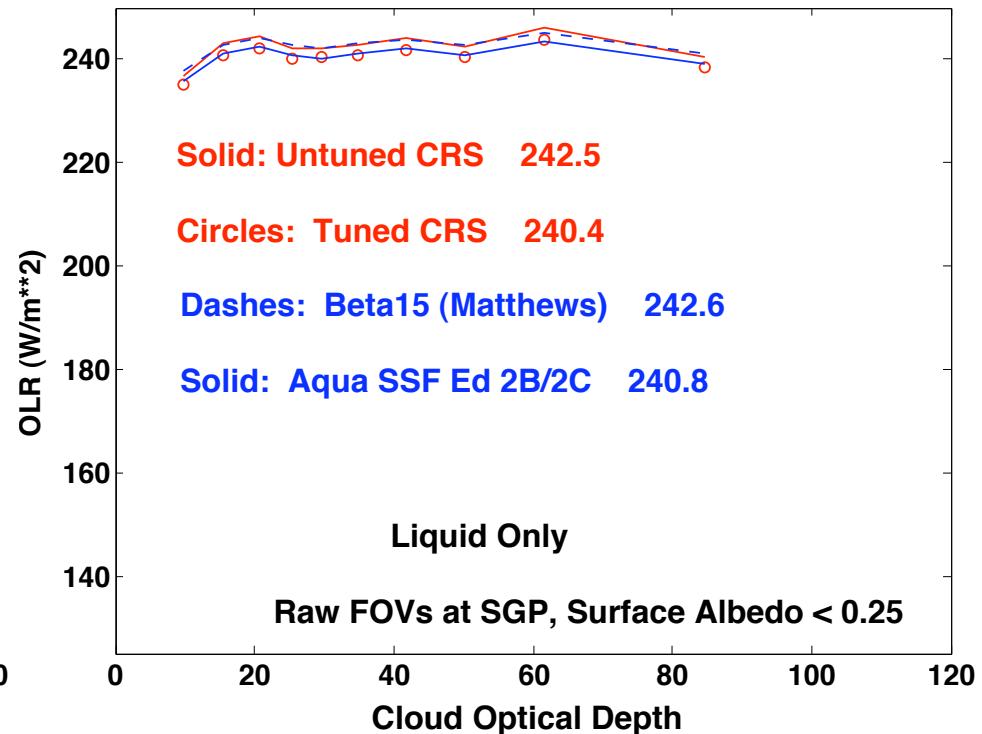
Use overcast to reduce effect of surface albedo.

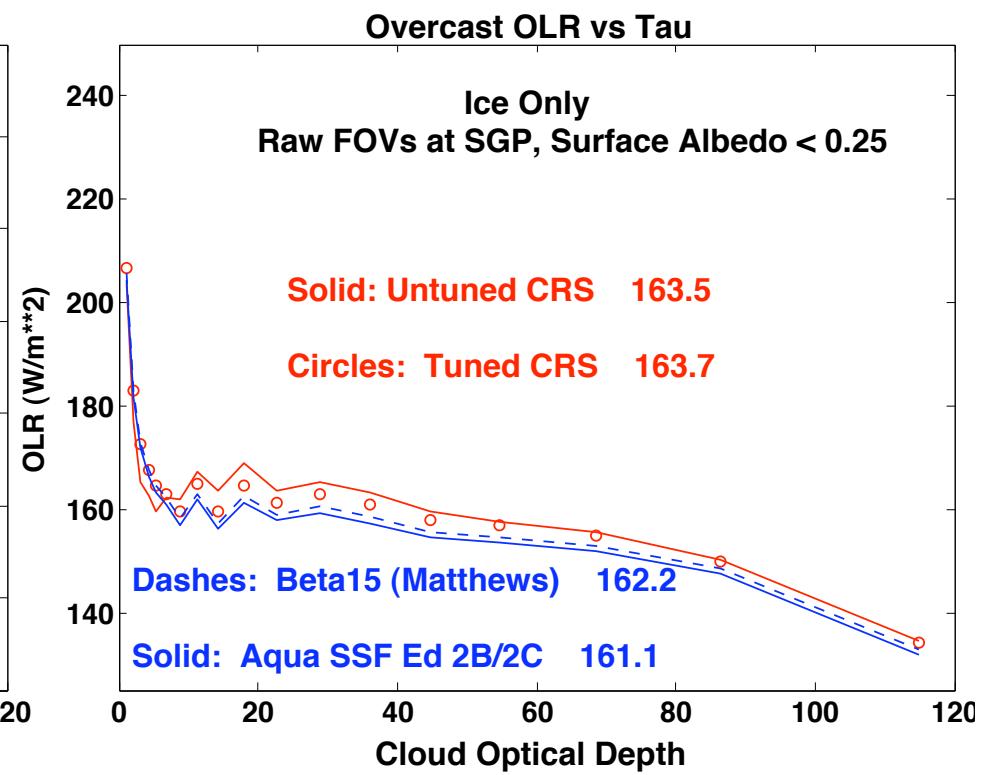
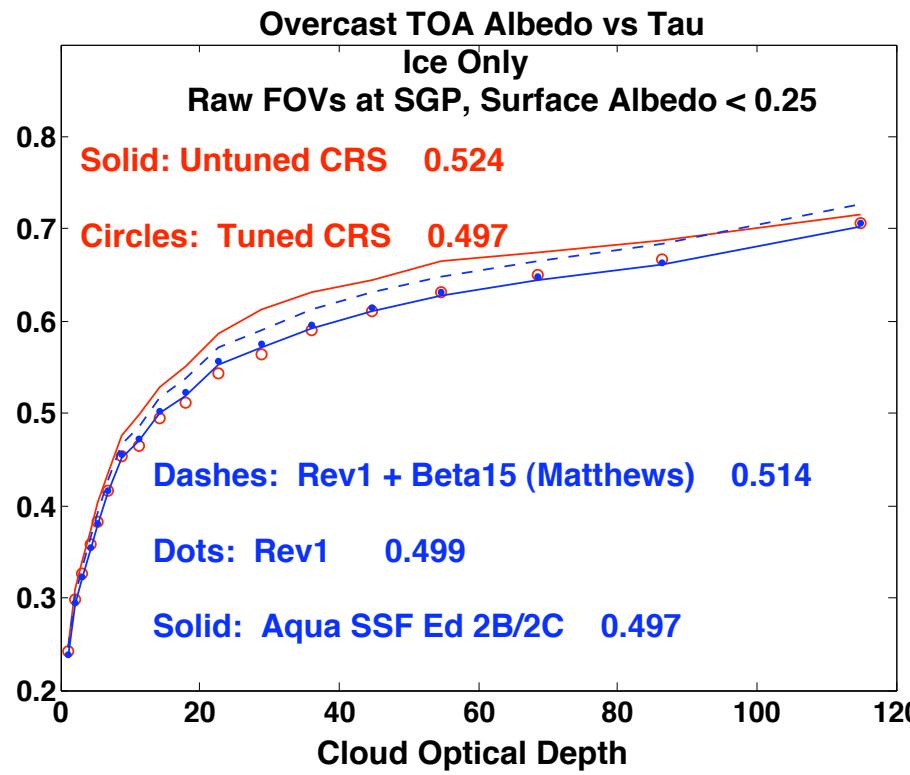


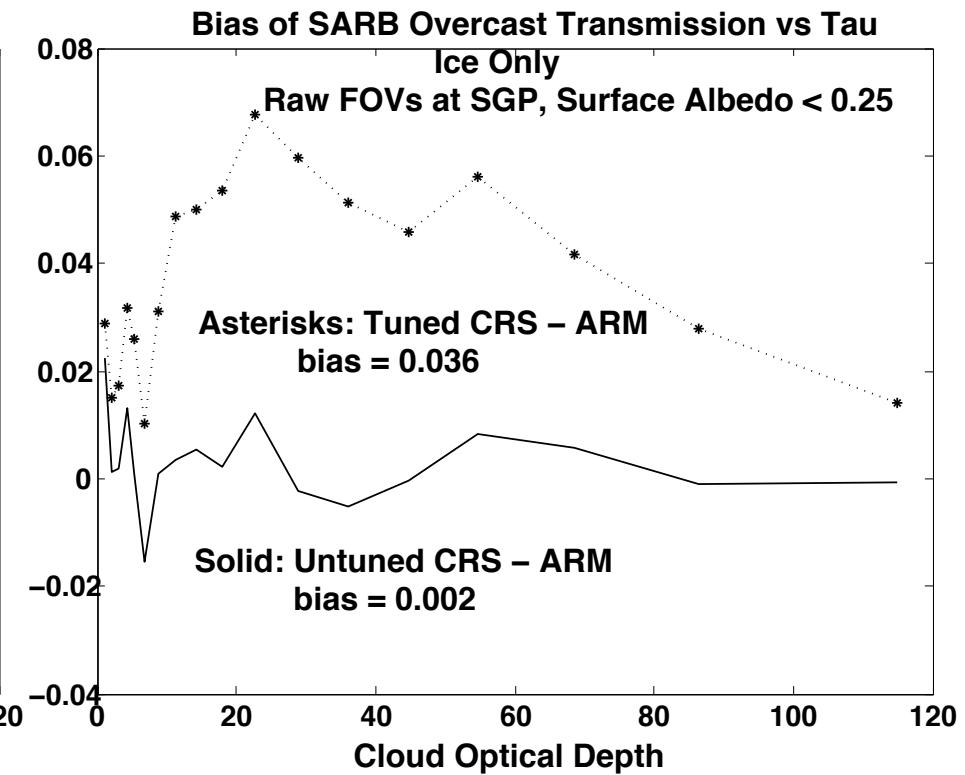
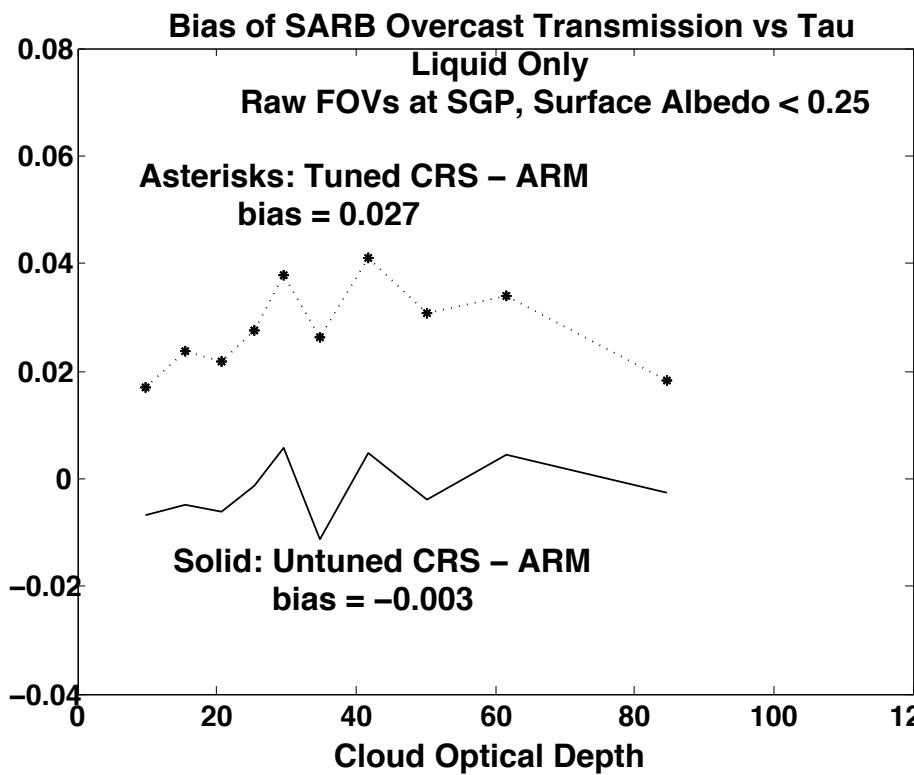
Overcast TOA Albedo vs Tau

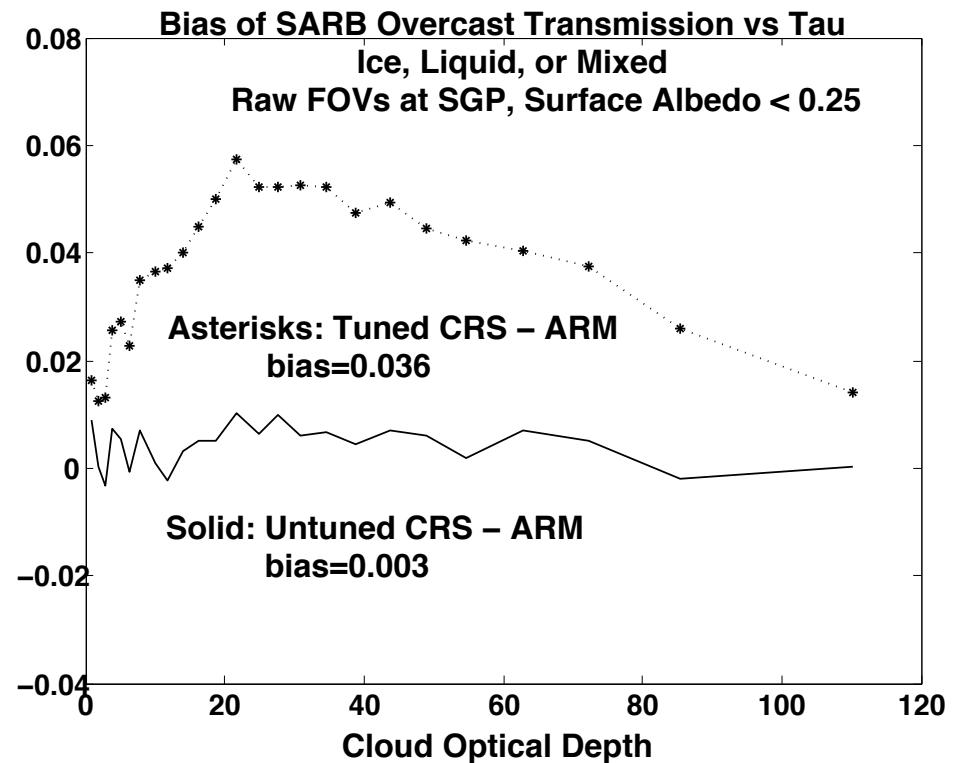
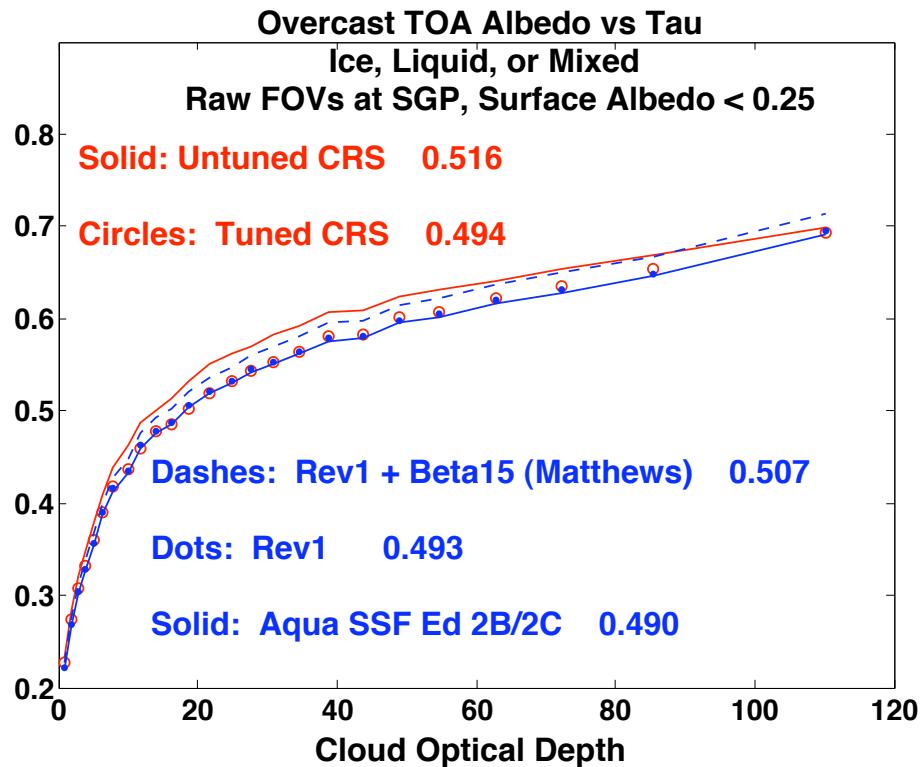


Overcast OLR vs Tau







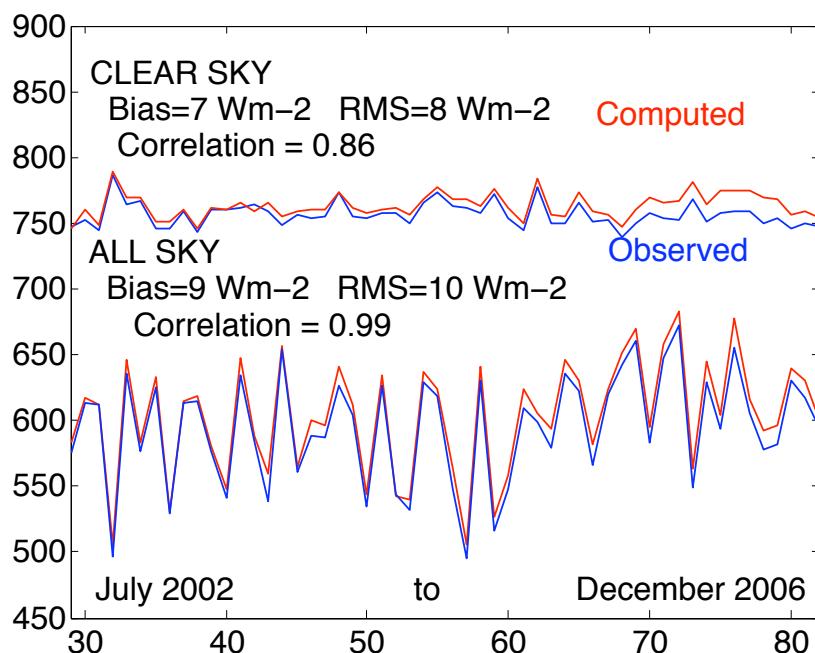


ARM SGP overcast comparison for SW suggests that satellite, model, and ground data will be consistent if CERES is “brighter”.

Matthews et al. paper in press.

What about the interannual variability (IAV) of SW at the surface?

Do we catch direct aerosol forcing well enough?



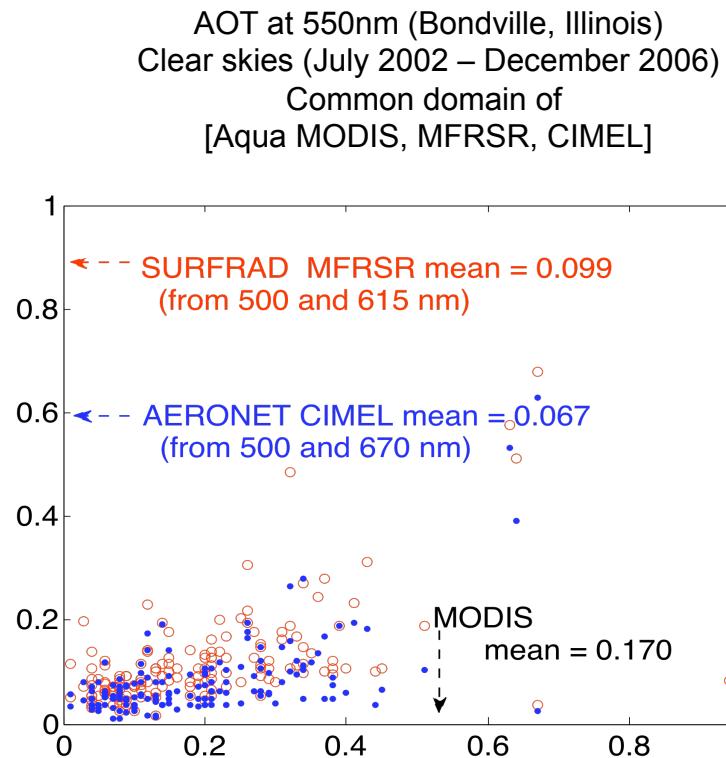
Bias of Computed Insolation
19 sites at ARM Southern Great Plains
July 2002 – December 2006
CERES Aqua CRS Edition 2B/2C (~1330 LST)

Insolation (ALL SKY)	Bias	RMS	Correlation	N
	Wm ⁻²	Wm ⁻²		
Instantaneous	9	97	0.94	27640
Deseasonalized Monthly	9	20	0.94	54
Grand Deseasonalized	9	10	0.99	54

Instantaneous: Snapshots at all 19 ARM sites in Southern Great Plains
Deseasonalized Monthly: Results for the typical site
Grand Deseasonalized: Consider all 19 sites as one giant site each month

Insolation (CLEAR SKY)	Bias	RMS	Correlation	N
	Wm ⁻²	Wm ⁻²		
Instantaneous	7	18	1.00	6325
Deseasonalized Monthly	7	13	0.85	53
Grand Deseasonalized	7	8	0.86	54

Aerosol optical depth (AOD) from MODIS vs ground photometer.



Computed Insolation (Bondville, Illinois)
Clear skies (July 2002 – December 2006)
CERES Aqua CRS Edition 2B/2C (~1330 LST)

Source of AOT	Bias	RMS	Forcing	AOT	N
	Wm^{-2}	Wm^{-2}	Wm^{-2}		
MODIS	-13	24	-27	0.170	90
AERONET	3	14	-11	0.067	90
MFRSR	-2	13	-16	0.099	90
Pristine	13	18	0	0	90

Even when satellite and surface are consistent for AOD, the modeled insolation has a bias. Uncertainty in aerosol optical properties (i.e., single scattering albedo) hit us here.

Computed Insolation (BSRN with AERONET)
 Clear skies (July 2002 – December 2006)
 CERES Aqua CRS Edition 2B/2C (~1330 LST)
 Bermuda, Bondville, Boulder, COVE, E13, Naru.

Source of AOT	Bias	RMS	Forcing	AOT	N
	Wm ⁻²	Wm ⁻²	Wm ⁻²		
MODIS	-6	20	-21	0.137	235
AERONET	4	16	-11	0.074	235

For only MODIS Collection 5 (May 2006 – December 2006):

Source of AOT	Bias	RMS	Forcing	AOT	N
	Wm ⁻²	Wm ⁻²	Wm ⁻²		
MODIS	-3	22	-14	0.124	42
AERONET	8	23	-7	0.059	42

Computed Insolation (SURFRAD sites)
 Clear skies (July 2002 – December 2006)
 CERES Aqua CRS Edition 2B/2C (~1330 LST)
 Bondville, Desert Rock, Fort Peck, Penn State, Sioux Falls, Table Mtn.

Source of AOT	Bias	RMS	Forcing	AOT	N
	Wm ⁻²	Wm ⁻²	Wm ⁻²		
MODIS	3	24	-21	0.147	329
MFRSR	7	20	-17	0.117	329

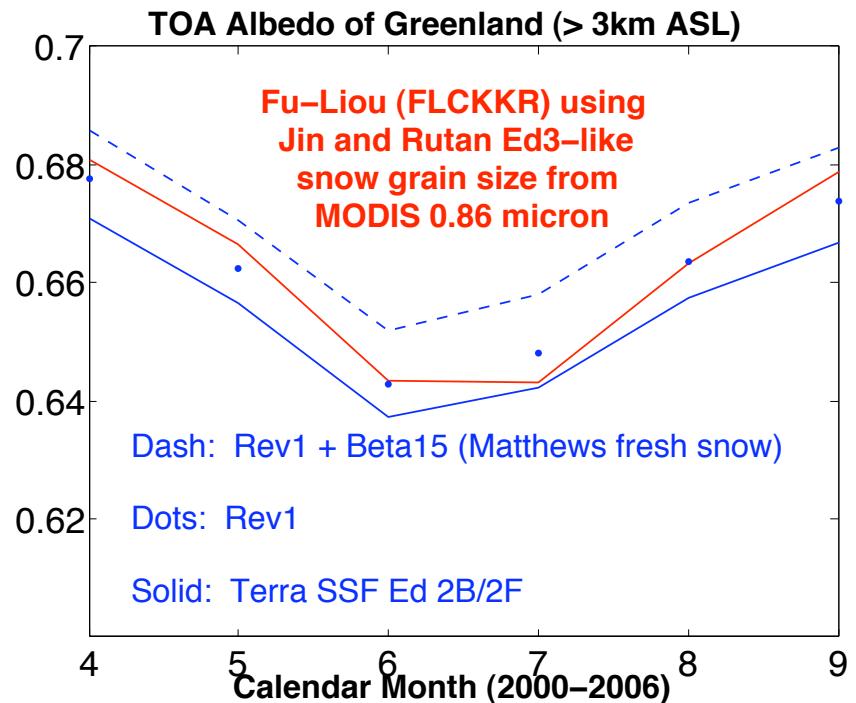
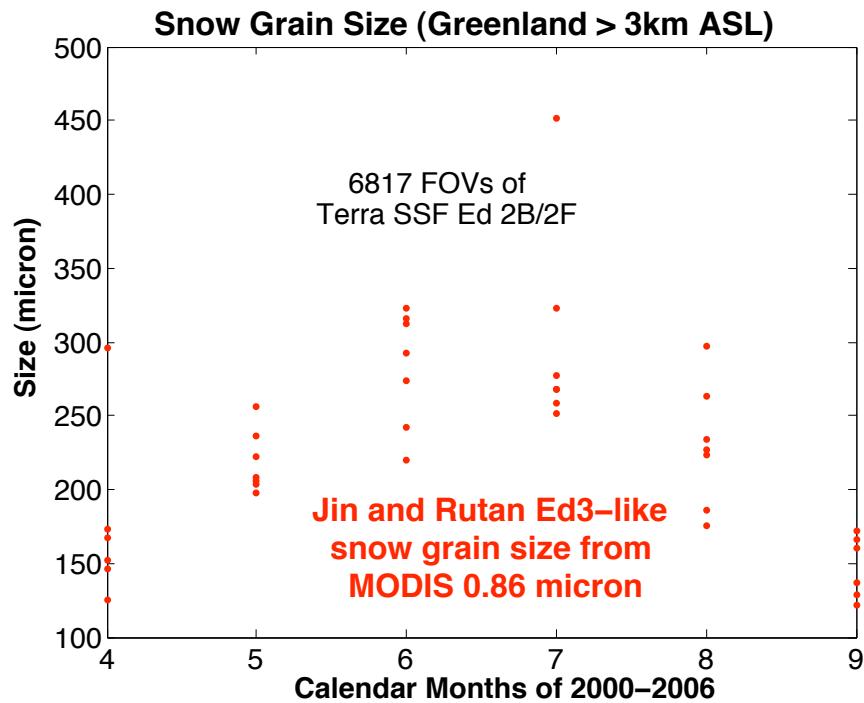
For only MODIS Collection 5 (May 2006 – December 2006):

Source of AOT	Bias	RMS	Forcing	AOT	N
	Wm ⁻²	Wm ⁻²	Wm ⁻²		
MODIS	14	25	-15	0.105	94
MFRSR	14	26	-17	0.110	94

Edition 3 will retrieve snow grain size.

Jin algorithm successful in Antarctic.

Try different channel for Greenland, which has larger grains.



Current ED2 Cloud SARB Inputs (Day)

- Cloud Visible Optical Depth (0.63 μ m)
- Phase (1 Water ,2 Ice)
- 3.7m Particle size Re/De (μ m)
- Cloud Top Pressure(hPa)
- Cloud Base Pressure(hPa)

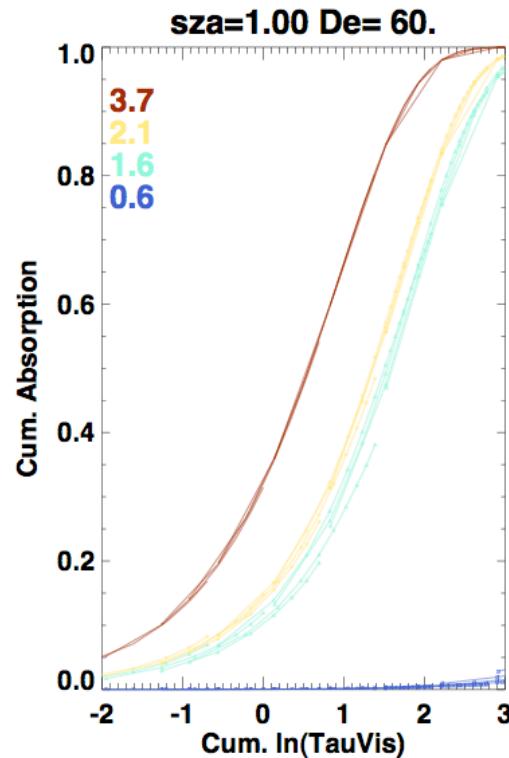
Additional ED3 Cloud SARB Inputs

- 2.1 or 1.6 Particle size Re/De (μ m)
- Asymmetry factor (0.63 μ m)
- Cloud Top Temperature(K)
- Cloud Base Temperature(K)

Proposed ED3 SARB Code Modifications:

- Use Cloud WG asymmetry parameter to determine Fu-Liou
Ice cloud aspect ratio to match Fu-Liou asymmetry
parameter. (Ice Cloud Only)
- Use Cloud WG multi-wavelength retrievals to construct in

2.1 and 3.7um Particle Size use in Ed3 SARB Vertical Profile Determination



It's well established that solar insolation vertical penetration is dependent on wavelength.

3.7μ is absorbed near top of cloud while 2.1μ and 1.6μ go deeper.

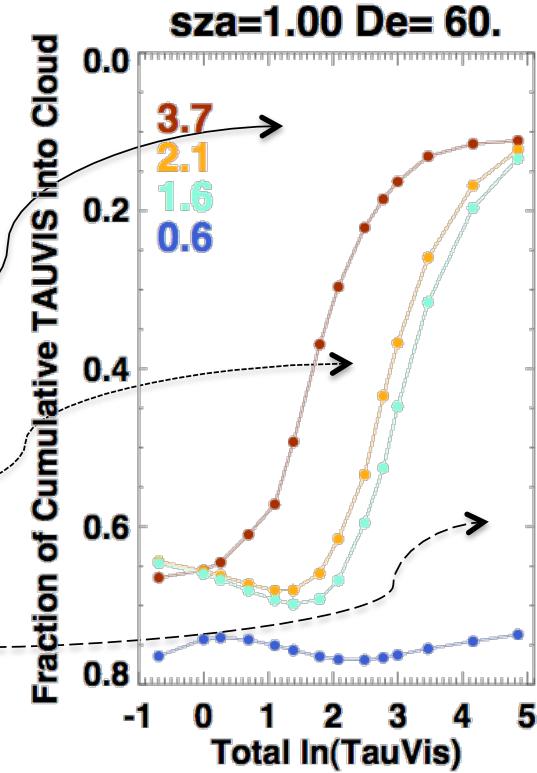
Idea:

Relate multi-wavelength particle size retrievals to a cloud vertical profile

Use 3.7μ size retrieval above red line

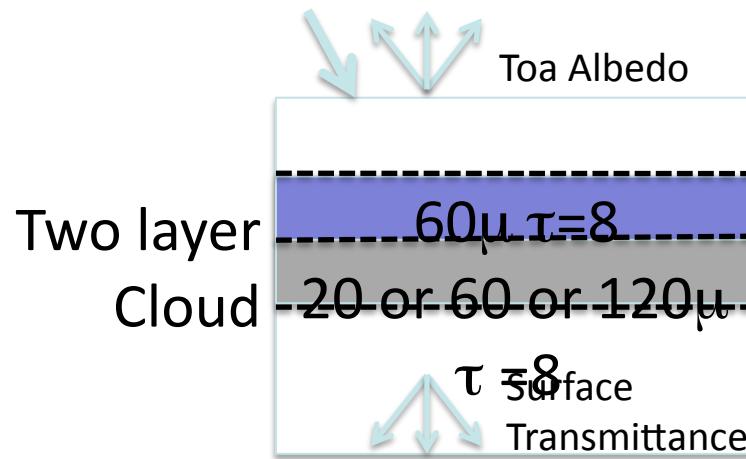
Interpolate between 3.7μ to 2.1μ , 1.6μ

Use 2.1μ or 1.6μ size retrieval below orange (2.1) or green (1.6) line



Here the fraction of the cumulative cloud τ where the cloud albedo goes to $1/e$ ($\sim 37\%$) of its top most value is plotted against the total cloud τ . Based on Fu-Liou for dry SAW atmosphere. Computations used for a Look-Up-Table (LUT)

2.1 and 3.7 μ m Particle Size use in Ed3 SARB Sensitivity Analysis



Method:

Fu-Liou two layer cloud with fixed top layer particle size. Showing sensitivity of TOA albedo and surface transmittance for broadband and bands containing (3.7, 2.1, 1.6 μ m) to a lower layer particle size. Each layer contains $\frac{1}{2}$ of the visible cloud

